

Measurements of the Aerosol Light-Scattering Coefficient at Ambient and 85% Relative Humidity on the ONR Pelican During ACE-2

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LONG-TERM GOALS

The ultimate goal of this study is the determination of aerosol hygroscopicity and its impact on physical (e.g., size) and optical properties (e.g., scattering coefficient) of marine aerosols on large spatial scales. Related to this, a methodology for retrieving the dry aerosol properties from ambient measurements on large spatial scales, for example, by satellite remote sensing, is of great interest.

OBJECTIVES

The immediate objectives of the study involve data analysis from two separate field studies already completed. The first such study is the ACE-2 study completed in the summer of 1997 and the second the DECS study completed this past summer (1999). Objectives for each study are given below:

- Determine the impact of humidity on the aerosol scattering coefficient for different aerosol types (ACE-2).
- Determine the impact of humidity on upwelling radiance from aerosol backscatter (ACE-2)
- Test the constancy of the dry aerosol number-to-volume ratio, and the impact of humidity on it, in marine air (ACE-2 and DECS).
- Explore the feasibility of remotely retrieving aerosol hygroscopicity.
- Explore the feasibility of a remote retrieval of dry aerosol volume and CCN number concentration (ACE-2 and DECS).

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- Explore the formation of new particles near clouds.

APPROACH

The approach utilized to measure the RH dependence of the aerosol light-scattering coefficient was described in the last annual report and will not be re-iterated here. The approach to appraising the constancy of the dry aerosol number to volume ratio is, in part, related to this. Once the functional dependence of the scattering on RH is determined, it can be applied to the measured ambient scattering (for which the measurement RH is known) to correct the values to low RH ($\sim 30\%$, i.e., "dry") for comparison with similarly corrected and simultaneous ambient measurements of the aerosol volume from the PCASP measurements.

To access the impact of humidity on upwelling radiance, and the closely related issue of remote retrieval of aerosol hygroscopicity and aerosol dry volume and CCN concentration, forward radiative transfer simulations (from the in-situ measurements of aerosol size and composition) are necessary. For the data gathered during ACE-2, the well-known 6S code has been utilized (Vermote et al., 1997). For the DECS data set, a version of the DISTORT radiative transfer code will be utilized (MODTRAN, Berk et al., 1998) together, of course, with the measurements themselves. For documenting particle formation near cloud, a suite of three CN counters, operating at different supersaturations, has been employed. The measurements were continuous (1 Hz) as the aircraft passed in and out of cloud, thus permitting assessment of small particle gradients near cloud.

WORK COMPLETED

In addition to the values obtained for the aerosol hygroscopicity parameter (κ) reported in last year's report for the ACE-2 data set, several other tasks have been completed. An assessment has been made of the constancy of the aerosol number-to-volume ratio for the ACE-2 data set. A preliminary assessment of the feasibility of a retrieval of the dry value of this parameter has also been made. The impact of hygroscopicity on upwelling irradiance due to aerosol backscatter for the ACE-2 data set has been examined.

RESULTS

Analysis of the ACE-2 data set has yielded a mean, dry aerosol number-to-volume ratio of $168 \pm 21 \mu\text{m}^{-3}$, in agreement with several previous studies in different marine locals. However, the mean value is quite "noisy," with a large standard error. This is in part due to uncertainties generated by the need to correct the measurement to "dry" conditions. Nevertheless, analysis suggests that this noise will render the remote retrieval of marine CCN concentration difficult when based on retrieval of the dry aerosol volume alone. This can be seen in Figure 1, which shows a comparison of CCN predicted from the calculated dry aerosol volume to actual CCN concentrations. On the other hand, if concurrent retrieval of both the dry volume and number-to-volume ratios (from the retrieved effective radius) is feasible, the recovery of actual CCN concentrations proved appreciably more accurate (Figure 2). These results have been reported in Hegg and Jonsson (1999).

Observed vs CCN predicted from v alone

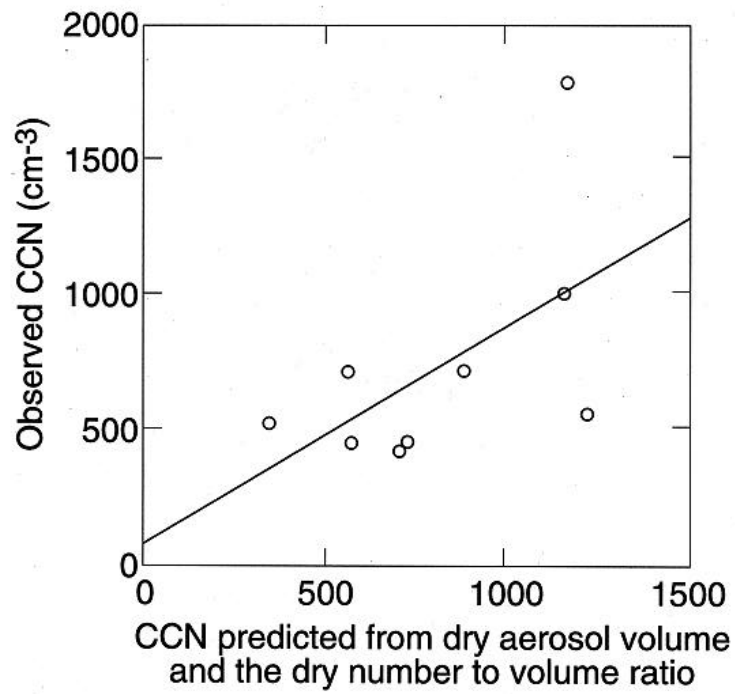


Figure 1.

Observed vs CCN predicted from v and n/v

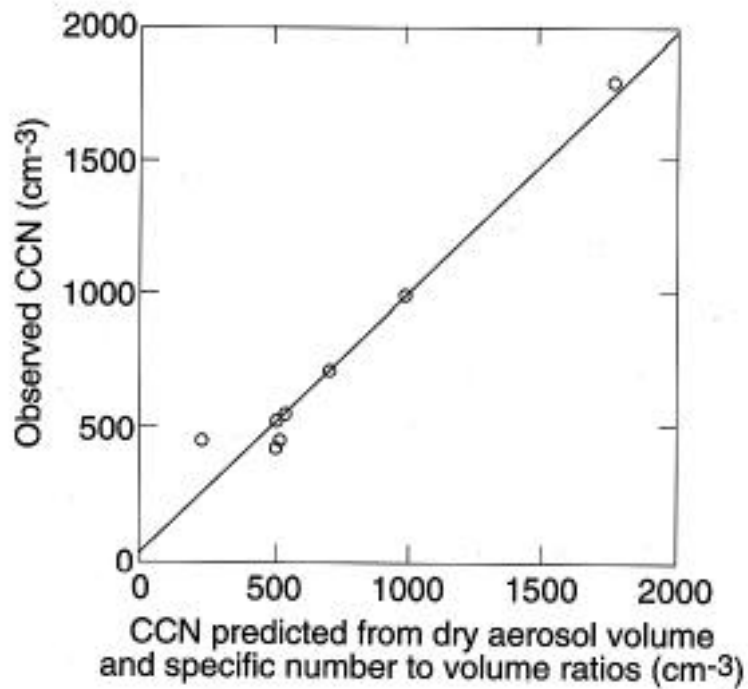


Figure 2.

The radiative transfer calculations demonstrating the separable impact of aerosol hygroscopicity on upwelling radiance, were carried out for the radiometer wavelength bands (and viewing angles) of both the MISR and MODIS radiometers. The most promising results were found for the near infrared bands of the MODIS sensor. These results are shown in Figure 3. It can be seen that, at least for the higher optical depths, the impact of hygroscopicity (γ) on the radiance does indeed suggest that retrieval of hygroscopicity is possible if estimate of the ambient RH with $\sim 10\%$ can be made. This analysis has been reported in Gasso et al. (1999).

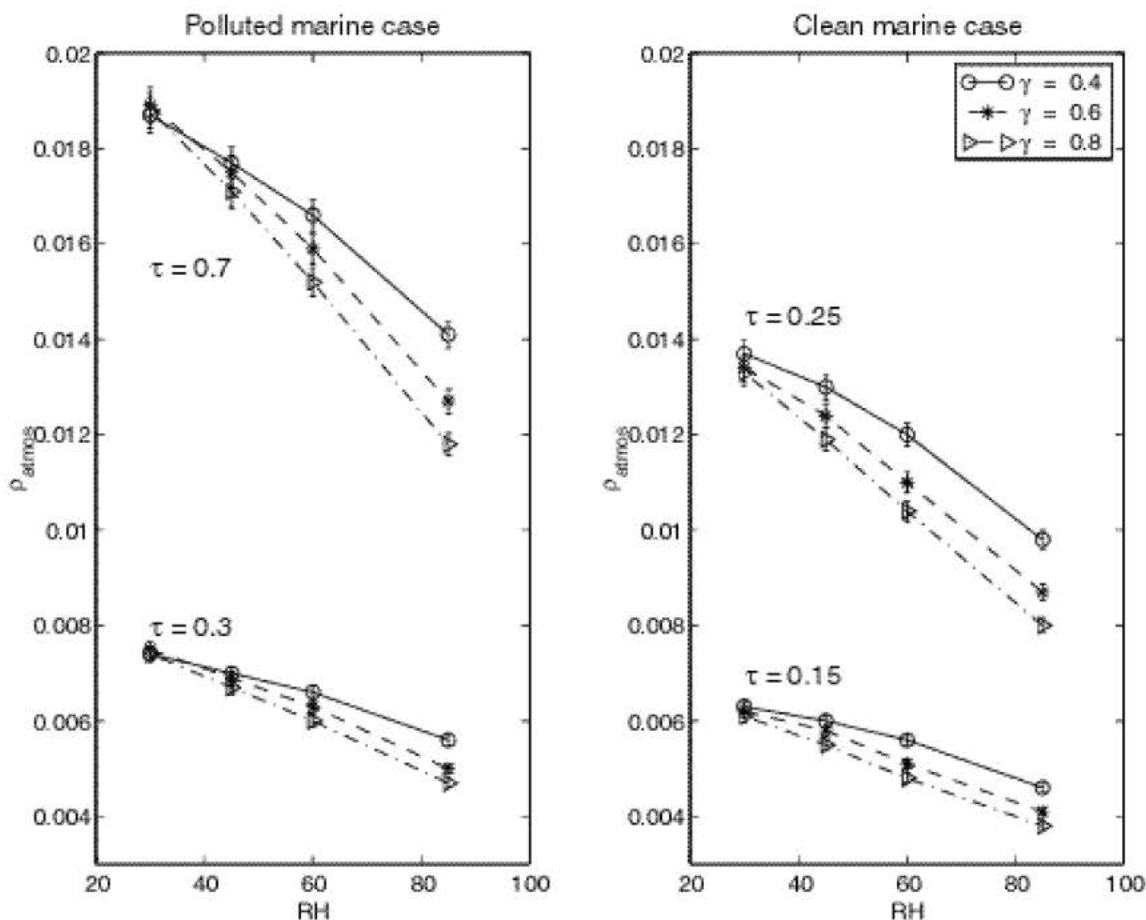


Figure 3.

Work has just commenced on reduction of data from the DECS study conducted this last summer. The analysis will center on analysis of particle formation and light scattering near clouds, and comparisons with MISR and MODIS retrievals.

IMPACT/APPLICATIONS

These results suggest that remote retrieval of both aerosol hygroscopicity and the CCN number concentration may be possible in marine air, where measurement by more conventional means is rare and expensive.

TRANSITIONS

As was the case with the ACE-2 data, the DECS hygroscopic data will be used by all participants in the study. More indirectly, the analysis of the potential for remote retrieval of aerosol hygroscopicity and of CCN concentrations should be of wide interest to the aerosol community.

RELATED PROJECTS

The impact of aerosol hygroscopicity on aerosol radiative properties, and the resultant impact on potential retrievals of dry aerosol parameters via remote sensing, is of great interest to both the MODIS and MISR science teams at NASA. We are cooperating with scientists on both teams.

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